HOW TO CONSERVE MATERIAL

BY

HARRISON E. HOWE

LECTURE No. 30
OF THE
FACTORY MANAGEMENT
COURSE AND SERVICE

VOLUME 8, LECTURE 2

INDUSTRIAL EXTENSION INSTITUTE
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After graduation from Earlham College in 1901, Mr. Howe was a student in the Graduate School at the University of Michigan. When the Sanilac Sugar Refining Company was formed he became chemist for that enterprise, leaving in 1904 to join the staff of the Bausch and Lomb Optical Company, where he served in various capacities, including that of Chief Chemist, until 1916. Meanwhile the degree of M.S. was earned at the University of Rochester. From 1916 to 1919 he was a member of the staff of Arthur D. Little, Incorporated; serving for more than a year as the assistant to the President of the Canadian corporation, Arthur D. Little, Limited, where he devoted himself to the study of commercial utilization of natural resources. During the latter part of the war Mr. Howe served in the Nitrate Division of Army Ordnance and is now Chairman of the Division of Research Extension, National Research Council. Throughout his professional career he has specialized in the application of science to industry. For some years a member of the American Chemical Society, Mr. Howe has served as Chairman of the Division of Industrial and Engineering Chemistry. He is now Secretary of that Division, Counsellor-at-large of the Society, and a member of its Advisory Committee. He is also a member of the American Institute of Mining and Metallurgical Engineers and at various times has been active in many other scientific and technical societies.

In this lecture, Mr. Howe shows broadly how, through the application of scientific control, material may be conserved by reducing rejections; by the selection of proper material; by the introduction of new methods, new equipment, or new material; by the utilization and prevention of waste, and by reclamation or salvage methods.

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Applied Salvage.—Among the many pastimes and hobbies which have been developed on a paying basis I have always been struck with the success of an Irishman who began to raise ducks in one of the small smelter settlements of the west; in fact he became so much concerned with raising ducks that he gave up his job in the mine and smelter and devoted his entire time to this peaceful occupation. He had gone to the superintendent with the story that while he enjoyed his work underground and elsewhere about the plant he was after all a simple minded fellow who delighted most in raising ducks. He might be a wonderful workman in other respects, but when it came to raising ducks he acknowledged no one as his equal. His experience was supposed to have dated from the days in old Ireland, and at length he was granted permission to put up a little dam across a gully and have certain mine waters diverted there to provide a suitable pond for his beloved ducks. This the superintendent was glad to grant after hearing his story, but by and by the growing wealth of the Irishman became so apparent that curiosity was aroused. It was found

that he was not so simple minded as he had claimed to be—by placing strips of iron in his duck pond he had been able to recover from the waste waters quantities of copper which, thus salvaged, had become the foundation stone of a fortune, which was rapidly growing. The ducks cannot be called decoys, but they certainly provided an excellent camouflage.

There are many instances of such wastes, the prevention and utilization of which plays such an important part in industrial conservation. Many of our industrial research laboratories devote their time to the study of wastes, and much of our academic research has somewhere in the future the possibility that the results may effect some economy in production.

Science an Aid in Conservation.—I think it would be proper to define industrial conservation as any method, plan or arrangement which effects economies either in raw materials, in labor or in overhead management. It all comes to the valuation of time and materials, which are the two great divisions making up the cost of manufacture and distribution. In this discussion I would like to emphasize how potent is applied science in affecting such conservation, and as no special problem is before us we can best argue the possibilities from what the past has shown us to be possible. If, as a result, you may be convinced that science applied in the proper direction in whatever industry you may be interested will enable you to make substantial progress, then the object of this discussion will have been accomplished.

Most men are agreed that if science is to have the greatest possible earning power for an industry, in-

dustry must make its scientific department an intimate, integral, internal part of its organization. In visiting the laboratories of numerous industries in the past I have often been struck with the lack of suitable facilities for attacking the problems which have been put up to the men in charge. Perhaps the superintendent or someone in authority has been convinced that they ought to do something along scientific lines and have set out to find some unoccupied corner that could be washed, provided with running water and gas, a table or two, and called a laboratory. It is wonderful how much men have accomplished amid such poor surroundings, and one can pay a tribute to their courage and optimism in carrying on research under such circumstances in a way that has won for them recognition in the organization and brought them suitable quarters in which to pursue their work.

Many manufacturers have only turned to scientific men when in trouble, just as we as individuals usually call upon a physician after we have been ill for some time and much advertised remedies have failed to effect a cure. It may be better to follow the Chinese plan and pay our physicians only when we are in good health. At all events the commercial laboratory has found an important field for its activities, being available in a consulting capacity upon troubles which arise in the plant and which those in the plant have been unable to solve. This fact alone indicates that they are not easy, and manufacturers do not always display the patience and faith that may rightfully be expected in the ultimate outcome when they place their work in the hands of a consultant.

Another one of the favorite plans is that of supporting a student, by means of a Fellowship, in a college or university, where he has the benefit of expert direction and where library facilities are available as well as the opportunity of rubbing elbows with scientists in other fields. There are abundant illustrations of wonderful achievements which have followed a sort of cross pollonization of the sciences. Frequently a man working in a given field will find a colleague engaged upon a problem quite unlike his own, yet having devised some special method or apparatus which fits in exactly with the solution of his own difficulties.

Still another method is the cooperative one where those having common interests pool their resources and support a laboratory, the results of which are made available to all the members of the Association. These Associations have served actually to elevate whole industries and, contrary to the expectations of some of the members, has rarely changed the relative positions of the leaders and the others composing the Association. Thus, in the Association engaged in improving malleable iron those whose product formerly had the greatest strength and uniformity still excel in these particulars, but at the same time the product of all members of the Association has been improved much to the benefit of the leaders as well as the others in that field of endeavor.

Where the Laboratory Helps.—But whatever method may be followed in applying science to effect industrial conservation the expense may seem large to those who have not had an opportunity to realize upon such

an investment, and it is well, therefore, to indicate some of the things that have been accomplished.

In Reducing Costs.—One of the less spectacular of the accomplishments is something that occurs every day and has to do with the use of the laboratory in securing the right materials to be used in manufacture. In many instances the cost of raw materials is quite insignificant as compared to the other costs that make up the total, such as the labor item. Anything that will ensure a decrease in the percentage of seconds that are inadvertently manufactured, or will guarantee that the finished product will have the desired characteristics, is obviously important. A striking example may be drawn from the automobile field where we have been taught that vanadium steel is largely used because of its great strength and ability to resist shock. It has these characteristics to a marked degree, but as compared with high carbon steel, which also has great strength, it possesses machineability, which makes it possible to work vanadium steel by ordinary methods. High carbon steel requires grinding and other expensive operations, so that a given automobile part which costs, finished, about $6.00 when made of vanadium steel, costs more than $13.00 if high carbon steel is employed. The result is practically the same. The difference is due to labor charges. The saving is made by choosing materials, with the help of the laboratory, which are the most desirable for the purpose.

In Minimizing Rejections.—A case once came to my notice where a certain part was being made of a steel either improperly chosen for the service to be per-

formed or subjected to unsuitable treatment in preparing the machined part, by heat treating, for its life work. These bits of metal were very small; in fact they were rollers of certain bearings. As made in that plant the labor charge against them was high; but because the whole process lacked suitable scientific control, approximately 60 per cent of the rollers, after all the work had been done upon them, failed and had to be discarded. Even those which came through sufficiently perfect for assembling could not be depended upon to stand up against any service. At last accounts this concern had not yet been convinced that a few dollars spent in scientific work would not only save them many dollars, but would be a guarantee against the failure of their product in use.

Contrasted with this is the case of a manufacturer who had a contract for a U-shaped metal piece used in the manufacture of an item of military equipment. These small pieces required to be case hardened after they were formed, and early in his work as high as 70 per cent of these pieces were discarded as useless because in the heat treatment they twisted and warped out of shape. This manufacturer, having had occasion before to call in a scientist, procured the services of an experienced metallurgist, who soon found the seat of the trouble and was successful in prescribing a remedy and in bringing up the percentage of acceptable pieces to more than 98 per cent. Indeed the results were so satisfactory that this plant thereafter received all the orders for the part in question.

Instances of this sort are not confined to the manu-

factures of small metallic articles. In one plant there were tons of steel billets rejected by inspectors because of imperfections that were only eliminated when science was given an opportunity to be of service.

Conservation Hinges Upon Research.—It must be recalled, however, that often savings which seem apparently easy to make in the light of our present knowledge were impossible until some of the fundamental principles now understood could be established through research in pure science. It is very much the same as in manufacturing itself where parts or whole machines can now be made because of improved tools. So, in science, laws and principles must first be established before we have tools with which to overcome problems which up to that time were thought incapable of solution. It was not until science and engineering provided the cement gun that we were able to make reservoirs and dams sufficiently water tight, nor could repairs in clay retorts be made with such facility and certainty previous to the development of this same device. The principle of the phase-rule diagram may be compared with this, and one victory which can be credited to this principle was that in the manufacture of optical glass where data assembled on the principle of the phase rule diagram enabled scientists to demonstrate their independence of secret methods and technique, and to calculate the necessary components of a complex silicate mixture, so that the finished product would come within one or two actual trials of having the desired refractive index, specific gravity, dispersion and other constants.

The lack of scientific control frequently spells disas-

ter, and a man who fails to appreciate its significance cannot hope to progress. I know of fewer better illustrations of the penny-wise-pound-foolish practice than the case of the man who sought to make potassium salts from silicates at a time when potash was selling around $400 per ton. Working with a felspar he was able to fuse a mass which had a certain small percentage of potash available and this when ground was useful as a fertilizer material, supplying potash and acting as a filler simultaneously. This fused product was sold on a guaranteed basis of available potash, and to come up to this guaranty it was necessary to analyze the raw materials, to obtain proper proportions and to know accurately the amount of available potash in the finished product. That is perfectly obvious, and yet because for some weeks the raw materials happened to be fairly constant in their values the manufacturer thought to save the few dollars cost of the analysis and dispensed with chemical assistance. It took him just three weeks to pile up and to ship enough material, which failed to meet the specifications, to bankrupt the entire enterprise and put him permanently out of business.

In working to specifications it is just as important from the money making standpoint not to give too much as it is not to give enough. There are very few instances where a manufacturer cannot afford to give something for good measure, but there has been many a case where due to a lack of accurate knowledge obtained by scientific methods an excess value was given in order to be sure that specifications would be met.

Conservation Through Electrical Research.—It is fascinating to consider how many new devices have been developed to make possible new accomplishments in industrial conservation. We might divide our subject according to apparatus and be surprised to learn how many are the fields in which they find successful application. The electric furnace is an example. Not only does it make it possible to produce alloy steels of uniform quality, but it enables the manufacturer to save expensive ingredients which under other methods of melting volatilize and oxidize to a cosiderable extent. The electric furnace also makes it possible to produce in large quantity the quality of special steels which in the olden days was exclusively the product of the small crucible. Such a device affords the advantages of qualitative production and quantitative in that we are learning how to control the reactions taking place with a degree of accuracy comparable to that employed in making an exact quantitative chemical analysis. Much of the waste in metal works, including such dirty materials as foundry sweepings, can be fed into the electric furnace and the metallic values recovered for use again. In fact, electricity is one of our best servants in industrial conservation. Electric refining has made it possible to utilize the complex zinc ores at Trail. As is well known the finest copper required for our electrical machinery is refined with a maximum of purity and a minimum of loss by electrolytic methods. It is by electrolytic methods also that gold and silver are refined with the greatest economy, and various compounds of lead such as worn out battery plates sometimes find their

way back to the metallic state for re-use through refining methods involving the use of electricity.

In one of the New England valleys where the production of brass in its various forms is a leading industry, so much metal found its way into the waste waters that the waters of the river were aseptic. Salts of copper are often used as poisons, but one can hardly afford to render aseptic a large body of flowing water. This condition having been brought to the attention of the manufacturers electrolytic methods were devised whereby the metal could be stripped from the outgoing water at a very considerable profit. Another outstanding application of electricity is the recovery of values by the Cottrell precipitation process. This, in brief, depends upon the use of a unidirectional electric current flowing between an electrode which is very efficient in the discharge of currents and another which is equally efficient in attracting to it such a discharge. The experiments of recent have shown us that electricity is in fact composed of innumerable tiny bits which have been called electrons. If a stream of fine particles, let us say dust, is carried through such an electrical field, the small particles making up the electric currents have a tendency to fasten themselves on the bits of dust which are thus attracted to one of the electrodes where, the currents having been discharged, they either cling to the electrode or fall in a mass. This is the principle of the Cottrell Precipitator; and while it seems simple when stated thus, it is in fact a complicated technical device which involves the study of the volume, the time, and the temperature, as well as

the character of the dust to be precipitated to make it applicable in its various fields. The use of this precipitator has resulted in real industrial conservation, for in such a case as the cement plant at Riverside, California, the dust thus separated from the stack gases has been found to carry enough potash to pay for the operation of the plant; while at the same time extensive litigation formerly carried on between surrounding farmers and the cement company has been made a thing of the past. There is no longer any dust to settle upon the countryside and stifle vegetation.

No doubt much of the fame which has been won by this and other methods of waste prevention has been due to the tremendous amount of waste to be recovered. However, this in no wise detracts from the value of such methods, for values running into the hundreds of dollars per day, if not thousands, have been won from waste gases and fumes in more than one plant. In other locations such volumes of waste materials can be recovered by this method as to embarrass the manufacturer in the disposition of these by-products. The statement has been made that in one of the great smelters enough arsenic could be recovered from waste gases to make its storage and disposition a greater problem than it is now in allowing its discharge into the air.

Conservation in Metal Extraction.—The introduction of the cyanide process made it possible to separate gold and silver from ores which up to that time had yielded to no process for the separation of these metals. For years potassium cyanide was the salt

employed and great quantities of potash, so necessary in agriculture and in the arts, was thus really wasted, for we now know that sodium cyanide will do as well. Isn't it strange how long it sometimes takes to learn these economies in industrial conservation? These delays are often due to prejudices which have no foundation in scientific fact, many of them being due to insistent advertising on the part of those interested in furthering the sale of a particular material.

A new era in the conservation of metal values in tailings, mine dumps, and low grade ores began with the introduction of the ore flotation process, concerning which we still know much less than is obviously desirable. Bubbles and films are being employed to treat thousands of tons of low grade material, and in the ore flotation process we have another example of how a method devised for one purpose may find a useful and important application in a distinctly different field. I have in mind work done at the Bureau of Standards in cooperation with the Navy upon the use of ore flotation to reduce the total ash content in certain coals, making them far more adaptable to special applications.

Applied Conservation: Fuel.—Closely allied to all metal interests is the fuel problem daily becoming more acute throughout the world. It was the idea of compacting more available heat units into restricted bunker capacity that turned the attention of the colloid chemist to the problem of so combining coal with oil as to produce a suspension which may be fired by the usual oil-burning methods. This called for the development of a colloidal fuel which has become a

reality. The next step has been the problem of finding ways to use any fuel oil and many low grade combustible materials which of themselves are unsatisfactory as sources of heat and power. This comprises peat, waste wood, low grade lignite, culm and waste resulting from the classification of anthracite and bituminous coal. If such materials can be brought into colloidal form and suspended in fuel oil the day when fuels shall become painfully scarce will be indefinitely postponed.

Another interesting field of research where metals and fuel overlap is in the briquetting of all types of fine particles. Briquetting is not new, but many of its applications are novel, and research in the field of briquetting is sure to effect decided gains in industrial conservation. It is well known that punchings and various scraps of sheet metal from manufacturing operations are remelted and that for some types of metals a size of scrap is reached below which it is unprofitable to endeavor to remelt the material. This is due to the oxidization and volatization of these scraps. A solution for this difficulty has been found in briquetting, where many sizes and shapes of scrap are compressed into suitable masses which can be fed into the crucible, the blast furnace, and the hearth. Even steel is now briquetted at the rate of many tons per hour in some plants. As for fuel, we are becoming familiar with the round-cornered cubical briquette originally composed of anthracite screenings and a suitable binder. As the differential between this type of fuel and the familiar anthracite and bituminous lumps becomes greater we will see much more briquet-

ted fuel used. It seems a simple task to mix such material with coal-tar pitch and pass it between rolls machined with depressions which match and form the briquette, but as a matter of fact the problem differs with nearly every material to be used and affords an opportunity for research in the development of binders that is indeed attractive. Some fuels require pre-treatment to make them suitable for briquetting, and at the present time, Canada is investigating the possibilities of carbonizing the lignites of the middle west and then briquetting, with a suitable binder, the coke-like residue which will be removed from the retorts.

Waste Paper.—The baling of waste paper, now practiced on a large scale, is somewhat analagous to briquetting, for it brings into a form easy to transport and handle the waste material which has been commonly burned to get it out of the way. The mounting prices for all grades of paper makes it advisable to burn none of it, but to conserve it and direct it back into channels of trade, where as raw material it is useful in producing some type of a sheet of fibre. The preparation of this waste paper to make it suitable for high grade pulps has in itself constituted a definite research problem. De-inking paper constituted a problem that has been pretty well solved, but any treatment must take into consideration varieties of sizing and filling materials that have come to be used in an effort to provide the lithographer and the printer with a surface capable of yielding the desired effects.

Copper, Lead, Zinc.—A few statistics will be helpful in emphasizing the commercial basis upon which

waste metals are recovered. In the tables of the geological survey such metals are designated as secondary metals. Secondary copper, including that in alloys other than brass, equalled about 29 per cent of the refinery output of primary copper—that is, new metal in the United States from all sources—and 37 per cent of such metal recovered from domestic ores. This quantity is 122,510 tons and was produced by refining plants working upon new metal as well as those dealing in second-hand materials. A large percentage of this secondary material originated from the manufacture of copper and brass articles and was turned over to dealers in part payment for new material. Remelted brass amounted to 328,000 tons and secondary lead to 41,146 tons. Recovered lead and alloys amounted to 55,954 tons. The main sources for this secondary lead is old pipe and cable, materials from acid chambers and tanks, and worn out batteries. It is interesting to note that many toys, heretofore imported, used a considerable quantity of impure lead scrap. There are two smelters in New Jersey, two in New York, and one in California, which work entirely upon zinc drosses. There is active competition for this class of waste, and the demand for scrap steel has led to the de-galvanizing of old zinc-coated scrap, thus rendering the sheet steel available. The zinc so recovered finds its way to market as carbonate or sulphate.

Tin.—Prominent among the metals recovered on a large scale is tin, which results from detinning tin plate scrap. There are three processes in general use, one involving the use of chlorine, another electrolytic

alkali, and the third, alkali saltpeter. The chlorine method depends upon the separation of the iron and tin by the fractional distillation of their chlorides. The scrap to be treated is heated to a temperature which brings about a vigorous reaction when chlorine is passed over the metal, whereupon both the tin and iron are volatilized as chlorides. Sometimes the scrap is melted and the chlorine passed through the metal held in a Bessemer Converter or some other type of suitable furnace. The metallic chlorides thus obtained are separated by fractional distillation. The tin chloride is converted into the oxide or the metal, while the iron is recovered finally as pure iron, chlorine gas being likewise recovered in a form to be utilized.

A more universal method of recovering the tin is in the form of tetrachloride, largely used for weighting silk. In a single year as much as 5,000 tons of tin in the form of tetrachloride has been used in the United States by the silk industry, and when the conservation of tin became important, during the war, steps were taken to be sure that those practicing the weighting of silk made full recoveries of the metal from spent liquors. The electrolytic alkali method gives the tin in the form of a sponge precipitate, which is remelted into pig tin, and the alkali-saltpeter method recovers the tin as an oxide, which is either reduced to the metal in a reverberatory furnace or, as the oxide, finds useful application in the enameling industry.

The cans which form the raw material for this industry are collected in the great centers principally by contractors who sort the waste of the cities as it passes along a picking belt. Some of the tin recovery

plants separate their raw material into scrap tin plate and old cans. The cans are washed with alkali and then briquetted into bales which are placed in drums and then treated with chlorine. More than 25,000 tons of old cans are treated each year, but the continuation of this industry on the present scale is doubtful in view of the increasing cost of labor required for sorting out the cans and preparing them for treatment. Perhaps the household may officially be called upon to assist in this phase of conservation by segregating the tin mass in the first instance, so that they may be collected in course of handling the city's garbage and and laid down at the detinning plant at as low a cost as possible. In considering the recovery and use of secondary tin it should be remembered that practically all of our tin comes from abroad, and that it is a comparatively high priced metal. The research worker is always tempted by the possibility of finding a cheaper material that will prove satisfactory as a substitute for tin and thereby reduce the cost of solder-bearing metals and several of the important alloys.

Aluminum, Nickel.—Another of the important metals recovered from scrap is aluminum. Much of this metal is used directly by foundries in preparing such alloys as a Standard No. 12, which must contain at least 92 percent of aluminum, the balance being copper. Recovered aluminum or secondary aluminum will analyze something over 98 percent aluminum, and the other metals which are likely to be present are copper, steel, iron and manganese. Another alloy into which secondary aluminum enters in quantity is one containing, in addition to aluminum, 4 percent of zinc and 8 per-

cent of copper. It will be seen then that this field is another in which scientific control of raw materials and prices makes possible decided economies through the use of cheaper metal mixtures which answer the purpose.

Nickel is another example of metal recovered on a commercial scale. This material goes into alloy steel and originates in monel metal, nickel, silver, and old nickel anodes from electro-plating.

Metallic Silver.—The difference in the appearance of a metal in an unusual physical state, as compared with its ordinary condition, has occasionally led to industrial losses. An example is the precipitation of metallic silver on glass surfaces in the production of high grade mirrors. This silver is usually precipitated as metal from a hydroxide solution from which it is separated from the oxygen by some reducing agent. Metallic silver in so fine a state of subdivision as is the precipitate under these conditions, looks like nothing else so much as mud and has been given that name in plants where considerable quantities originate. This drab colored material has often been allowed to run down the sewers, the management being under the impression that the material was worthless. Having a large surface in comparison with its weight this material may easily float away and in its recovery devices have been arranged to hasten its precipitation. It is not difficult to prepare either metallic silver or the nitrate from this mud and to use it subsequently on other mirrors. In this connection it might be pointed out that in recent years scientists have learned how to so control the deposition of this silver as to

produce a larger percentage of first grade work in the first instance, also methods for eliminating pinholes in the silver film on the mirror and ways of having the silver precipitate uniformly and slowly, as well as completely, from the solution, thereby conserving the time of the operatives and expensive materials. Research has been directed as much toward this factor of saving the time of operatives as it has in conserving materials. The two are often bound up together.

High-Speed Tools.—We are beginning to appreciate that it would be desirable to maintain a high scale of wages for labor, but that in order to do so it will be necessary for labor to produce more in a given unit of time or for a given unit of payment than is now the case. This can sometimes be done by such improvements as has been given industry through the production of high speed tools.

The operation of tools at high speed, particularly where metals are concerned, is accompanied by the production of temperatures which are almost sure to destroy the temper of the tool and rapidly wear down the cutting edge. A corps of scientists have been constantly at work upon this problem, and their success has been enough to afford great encouragement. The problem involves improvements in metals, improvements in machines which drive the tools, and in better cooling and lubricating mediums. It has been found that a plant equipped with carbon steel tools becomes immediately capable of producing approximately three times as much work in the same length of time with the same mechanical equipment and the same operatives if the modern tungsten tool

steel is installed. These tools can be driven three times as fast or three times as far in the same unit of time as the older type of tool without being deformed or greatly changed in the increased heat. That constitutes the whole story. Tungsten steel is now being crowded for first honors by other alloys, such as the one comprised of cobalt, chromium and tungsten. There are those who claim that this newer alloy is 150 percent as efficient as the tungsten steel, and it is known that the new alloy performed very creditable service under the pressure of the war emergency.

Machining Operations.—The research laboratory, in cooperation with the plant using the electric furnace, has also developed steel which retains its dimensions and shape when hardened, and it therefore becomes possible to produce by punch and die methods parts would otherwise have to be machined. This is because some intricate dies cannot be fashioned from prehardened steel, and yet they cannot perform their duties unless they are hardened. The advantage is therefore apparent when a steel is produced of a softness to allow machining and of a character to allow hardening without deformation. Die casting is another example where science has come to the aid of industry and effected conservation in industry through the saving of time, which is money. Extrusion is another modern method, and electric welding has opened up a new field because of its superiority for some purposes over acetylene, or gas welding, or the thermit process, which is so efficient where large masses of metal are required in addition to the welding itself.

Welding.—Welding effects considerable economies daily, and in sheet metal work has made possible perfectly satisfactory products which could not have been put together so well or so rapidly if bolts, screws, rivets or soldering had been used. Spot welding has been developed to the place where a perfect union of metals can be depended upon, and by employing electrodes of various peculiar shapes nearly any condition can be met. The success of this type of electric welding has encouraged research to the point where welding interests have come together in a society which is directing its efforts toward learning the best processes for particular work and improved practices without regard to furthering any particular process.

One of the most striking examples of the service which welding can render is to be found in the repair of German merchant ships which were in American harbors. It was largely through welding and the repairs made possible by employing welding apparatus that these vessels could be put into service in months as compared with the years reckoned by those responsible for the attempted destruction of the special machinery.

Electro-plating.—Electro-plating has been another factor in industrial conservation. The principle not only is used to coat a baser metal with something designed either to improve its wearing qualities or protect it, but has also been applied in metal cleaning, the stripping of base metals and in making a type of etching. Research has devised ways for speeding up electro-plating, both by devising baths in which plating can be carried on in a fraction of the time

formerly required, and also in the design of mechanical devices for the plating of small articles without the necessity of wiring each individual piece, as was the former practice.

Metal Coating.—While speaking of metal coatings the introduction of compressed air in connection with spraying devices for japanning and lacquering must be mentioned, for they have done as much toward giving a more uniform coating as any other improvement. At the same time the element of time saved is not inconsiderable. There has always been a certain fire hazard in japanning and lacquering, and one of our research laboratories directed its efforts toward lessening that hazard, the primary interest being to make safe the use of special ovens in which the concern was interested. The effort was successful, and lacquers in which the inflammable, volatile solvent is replaced by water are now available. This achievement has been made possible through the application of the principles of colloidal chemistry, ways having been devised for saponifying the waxes and gums in an aqueous medium rather than by dissolving them in an inflammable solvent. The conservation effected is assured not only by the saving of solvent, but by the elimination of the danger of considerable personal injury and property loss involved in the use of more dangerous materials.

Textiles.—In this discussion we have drawn our examples largely from the metal field, but there are other cases equally striking to be found in practically every corner of industry. The accurate measurement of cotton fibres conducted in a research laboratory

disclosed the fact that a certain mill actually spun fibres one and one-eighth inch in length, whereas they were careful to purchase one and one-quarter inch staple. There is a difference in the value of cotton fibre, one of the determining factors being the length of staple. By changing the setting of the machinery it was found possible to eliminate the breaking of the fibre, which was responsible for the reduction of one-eighth inch in its length, but it was also demonstrated in the plant, although inadvertently, that the quality of the goods which the mill desired to make could be produced from the shorter and somewhat less expensive fibre.

The textile industry gained enormously when methods of bleaching by chemical means were devised. Formerly all fabric was bleached by being spread upon the grass in the sunlight, but today as good a job can be done by properly controlled chemical methods. At one time the reactions involved in this bleaching were not well understood; and in one instance where the process was believed to require thirty hours for its completion, scientists were able to show that by the proper control of temperatures and pressures this reaction could be made to go forward to completion in forty-five seconds, thereby effecting a saving of fourteen-fifteenths of the capital which was necessary for apparatus, labor, and interest on the values of the stock in process.

Corrosion.—Corrosion is one of our worst enemies, and great progress will have been made when we can successfully combat it in all its phases. Much has been learned on the subject, examples being the creosoting

of timber for special purposes and the development of numerous paints, bituminous coatings, and a variety of varnishes, some of which involve the use of synthetic gums and waxes which are products of the laboratory. New alloys which resist corrosion have been devised and are extensively used in fittings, valves, and for exterior construction, particularly in roofs. We have just begun to use sheet zinc as roofing material.

One method of defence has involved rendering the corrosive agent less virile in its attack. The experience of a New York building will illustrate the point. It is only in recent years that we have used great quantities of aerated water. Such water carries oxygen to iron pipes in a way to promote corrosion, and in the building in question it was found that the plumbing would soon have to be replaced unless something was done to retard corrosion. One can well imagine the feelings of owners confronted with the expense of replacing the plumbing, especially under present-day conditions, and in view of the fact that it was so placed as to make necessary a practical reconstruction of a part of the building. Scientists reasoned that if the water could have its appetite for iron satisfied before it went into the pipes corrosion could be stopped, and this was actually accomplished by providing a tank fitted with iron plates and other pieces put there to be corroded and easily replaced with fresh material when necessary. The saving ran into many figures.

Differences Between Success and Failure.—The days when rule of thumb methods can be made to answer

have passed for the majority of industries. It has been pointed out that in many cases the smaller industries which look upon their larger fellows as those particularly favored by circumstances, by large capital at their disposition or by some favorite treatment, for their success, fail to appreciate that in many instances the difference between them is largely a difference in the appreciation of how industrial conservation can be effected by the consistent, sustained and continued application of scientific principles and scientific methods to their problems. A few examples have been given above of what has been accomplished. This list might be extended almost indefinitely, and in many books will be found in detail the reactions involved in effecting a certain prevention of waste or waste utilization. In many cases a science has to be built up before the industry can profit by it. Those industries founded upon a science are indeed fortunate, but those who have not yet learned from experience the advantages which science offers them have encouragement to begin their investment in research from what has been achieved under the direction of their fellows in other fields of endeavor.